We claim:

1. A method of processing a received signal y to produce a channel estimate comprising:

(a) decoding the received signal y to form data s;

(b) forming a convolution matrix $\hat{S}$ from the data s;

(c) forming a matrix F from the data s, wherein the matrix F results from forming the matrix $\hat{S}$ as a convolution matrix; and,

(d) performing a conjugate gradient algorithm to determine the channel estimate, wherein the conjugate gradient algorithm is based on the received signal y, the matrix $\hat{S}$, and the matrix F.

2. The method of claim 1 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T \hat{S} d_k ,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

3. The method of claim 1 wherein the forming of a matrix $\hat{S}$ from the data s comprises:

forming a matrix S from the data s; and,

forming the matrix $\hat{S}$ from the matrix S by setting certain values of the matrix S to zero;

and wherein the forming of a matrix F from the data s comprises:

forming the matrix F from the matrix S by setting to zero the values of the matrix S not set to zero during the forming of the matrix $\hat{S}$.

4. The method of claim 3 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T\hat{S}d_k,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

5. The equalizer of claim 1 wherein the performing of a conjugate gradient algorithm to determine the channel estimate h comprises performing the following algorithm:

(1) $\hat{y} = y - Fh_1,$

$r_1 = \hat{S}^T\hat{y} - \hat{S}^T\hat{S}h_1$

(2) For k = 1 to n, iteratively calculate

(a) $d_k = r_k + \beta_k d_{k-1}$

(b) $h_{k+1} = h_k + \alpha_k d_k$

(c) $r_{k+1} = r_k - \alpha_k q_{k-1}$

where h_1 is an initial value of the channel estimate, where $\beta_1 = 0$, $\beta_{k\geq 2} = \frac{r_k^T \bullet r_k}{r_{k-1}^T \bullet r_{k-1}}$, where $\alpha_k = \frac{r_k^T \bullet r_k}{d_k \bullet q_k}$, where $q_k = S^T S d_k$.

6. The method of claim 5 wherein the performing of a conjugate gradient algorithm comprises determining the quantity q_k by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

7. The method of claim 5 wherein the forming of a matrix $\hat{S}$ from the data s comprises:

forming a matrix S from the data s; and,

forming the matrix $\hat{S}$ from the matrix S by setting certain values of the matrix S to zero;

and wherein the forming of a matrix F from the data s comprises:

forming the matrix F from the matrix S by setting to zero the values of the matrix S not set to zero during forming of the matrix $\hat{S}$.

8. The method of claim 7 wherein the performing of a conjugate gradient algorithm comprises determining the quantity q_k by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

9. A method of processing a received signal y comprising:

(a) decoding the received signal y to form data s;

(b) forming a convolution matrix $\hat{S}$ from the data s;

(c) forming a matrix F from the data s, wherein the matrix F results from forming the matrix $\hat{S}$ as a convolution matrix; and,

(d) performing a conjugate gradient algorithm based on the received signal y, the matrix $\hat{S}$, and the matrix F.

10. The method of claim 9 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T\hat{S}d_k ,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

11. The method of claim 9 wherein the forming of a matrix $\hat{S}$ from the data s comprises:

forming a matrix S from the data s; and,

forming the matrix $\hat{S}$ from the matrix S by setting certain values of the matrix S to zero;

and wherein the forming of a matrix F from the data s comprises:

forming the matrix F from the matrix S by setting to zero the values of the matrix S not set to zero during forming of the matrix $\hat{S}$.

12. The method of claim 11 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T\hat{S}d_k,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

13. A method of processing a received signal y comprising:

(a) decoding the received signal y to form data s;

(b) forming a convolution matrix $\hat{S}$ from the data s;

(c) forming a matrix F from the data s, wherein the matrix F results from forming the matrix $\hat{S}$ as a convolution matrix; and,

(d) performing a conjugate gradient algorithm based on the received signal y, the matrix $\hat{S}$, and the matrix F, wherein the conjugate gradient algorithm includes forming FFTs based on the received signal y, the matrix $\hat{S}$, and the matrix F, multiplying the FFTs to form a multiplication product, and forming an inverse FFT of the multiplication product.

14. The method of claim 13 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T\hat{S}d_k,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

15. The method of claim 13 wherein the forming of a matrix $\hat{S}$ from the data s comprises:

forming a matrix S from the data s; and,

forming the matrix $\hat{S}$ from the matrix S by setting certain values of the matrix S to zero;

and wherein the forming of a matrix F from the data s comprises:

forming the matrix F from the matrix S by setting to zero the values of the matrix S not set to zero during forming of the matrix $\hat{S}$.

16. The method of claim 15 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T\hat{S}d_k,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

17. A method of processing a received signal y to produce a channel estimate comprising:

(a) decoding the received signal y to form data s;

(b) forming a convolution matrix $\hat{S}$ from the data s;

(c) forming a matrix F from the data s, wherein the matrix F results from forming the matrix $\hat{S}$ as a convolution matrix; and,

(d) performing a conjugate gradient algorithm to determine the channel estimate, wherein the conjugate gradient algorithm is based on the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein the conjugate gradient algorithm includes forming FFTs based on the

received signal y, the matrix $\hat{S}$, and the matrix F, multiplying the FFTs to form a multiplication product, and forming an inverse FFT of the multiplication product.

18. The method of claim 17 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T \hat{S} d_k ,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

19. The method of claim 17 wherein the forming of a matrix $\hat{S}$ from the data s comprises:

forming a matrix S from the data s; and,

forming the matrix $\hat{S}$ from the matrix S by setting certain values of the matrix S to zero;

and wherein the forming of a matrix F from the data s comprises:

forming the matrix F from the matrix S by setting to zero the values of the matrix S not set to zero during forming of the matrix $\hat{S}$.

20. The method of claim 19 wherein the performing of a conjugate gradient algorithm comprises determining a quantity q_k according to the following equation:

$$q_k = \hat{S}^T \hat{S} d_k,$$

wherein d_k is dependent upon the received signal y, the matrix $\hat{S}$, and the matrix F, and wherein q_k is determined by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.

21. The equalizer of claim 17 wherein the performing of a conjugate gradient algorithm to determine the channel estimate h comprises performing the following algorithm:

(1) $\hat{y} = y - Fh_1$,

$r_1 = \hat{S}^T\hat{y} - \hat{S}^T\hat{S}h_1$

(2) For k = 1 to n, iteratively calculate

(a) $d_k = r_k + \beta_k d_{k-1}$

(b) $h_{k+1} = h_k + \alpha_k d_k$

(c) $r_{k+1} = r_k - \alpha_k q_{k-1}$

where h_1 is an initial value of the channel estimate, where $\beta_1 = 0$, $\beta_{k\geq 2} = \dfrac{r_k^T \bullet r_k}{r_{k-1}^T \bullet r_{k-1}}$, where $\alpha_k = \dfrac{r_k^T \bullet r_k}{d_k \bullet q_k}$, where $q_k = S^T S d_k$.

22. The method of claim 21 wherein the performing of a conjugate gradient algorithm comprises determining the quantity q_k by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of d_k, by multiplying the first, second, and third FFTs to produce a multiplication

result, and by forming an inverse FFT of the multiplication result.

23. The method of claim 21 wherein the forming of a matrix $\hat{S}$ from the data s comprises:

forming a matrix S from the data s; and,

forming the matrix $\hat{S}$ from the matrix S by setting certain values of the matrix S to zero;

and wherein the forming of a matrix F from the data s comprises:

forming the matrix F from the matrix S by setting to zero the values of the matrix S not set to zero during forming of the matrix $\hat{S}$.

24. The method of claim 23 wherein the performing of a conjugate gradient algorithm comprises determining the quantity q_k by forming a first FFT of the matrix $\hat{S}$, by forming a second FFT of the matrix $\hat{S}^T$, by forming a third FFT of the d_k, by multiplying the first, second, and third FFTs to produce a multiplication result, and by forming an inverse FFT of the multiplication result.